INTERVIEW WITH LOWELL ZOLLER
INTERVIEW BY STEPHEN P. WARING
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1. WARING: ...got involved with this work here at Marshall?

2. ZOLLER: Yes. Prior to coming to Marshall I worked for the Aircraft Nuclear Propulsion Division of the General Electric Company. We were engaged in the aircraft nuclear propulsion program. I was involved in the nuclear reactor end of it, particularly in the shielding radiation effects. We had a program that was ready to go into hardware testing. We had the hardware to the point where we could have built a nuclear turbo jet for testing, when the program was cancelled. So at that time, I was looking around for some other program to go to. The NERVA Program was just getting off the ground. I had made contacts with a lot of the people who were involved in the NERVA programs through the Aircraft Nuclear Programs. Among a variety of alternatives I chose to come to Marshall to work on the NERVA Program for a period of three years and then quit and go into industry. So, I have been here for thirty years!

I came into the materials branch of what at that time was PVE, Propulsion Vehicle Engineering Laboratory, working as a project engineer on the material aspects of NERVA. Then from there branching out from the material aspects of every other program that we were engaged in. From there, when we formed program development, I went with that organization and served as Chief Program Control. Then as the Project Manager for the Research and Applications Module. From there went with the Shuttle Program in the external tank. Then I went through almost everything else that we have been involved in.

3. WARING: What was the Research and Applications Module?

4. ZOLLER: The Research and Applications Module was a forerunner of the Spacelab.

We did a "Phase B" study which upon its conclusion, we took the results to the European Ministers, who were the delegates to the European Space Council. [We] presented to them a summary of the results and also made an assessment of their ability to undertake the Spacelab program and basically convince them of the opportunities to do that program and also their abilities to do it.

Then at some time later I did also have the opportunity to do a tour of duty in Germany. I was assigned as the Senior Management Advisor to the European Space Agency.

As you had mentioned, after my job with the external tank, then the Center created the Special Projects Office, which I headed up. Under that we did the Lageos, solar heating and cooling. There were a number of smaller payload programs, many of which incorporated the materials processing in space, which at a time later became a separate project, material processing in space. I headed that organization.

I have had an opportunity with my current assignment to work in every organization on the Center.

5. WARING: Well, that gives you a good perspective! Well, lets go through some of these programs, one by one. What was Marshall's role in NERVA? Was it essentially NASA's lead center?

6. ZOLLER: Yes, because it was a propulsion project. We were looking, of course, for a nuclear upper stage for lifting heavy payloads for long duration flights in space. The principle activity culminated in some nuclear rocket firings at the national reactor test station in Idaho Falls, Idaho. We were engaged in the vehicle design, not so much the motor aspects of it, although we were involved in that. PEC was involved from the motor standpoint, although NASA did have quite a bit of influence in that area. The Lewis Laboratory was involved in it. We were working on the design for the stage hardware for

that. That was in parallel to the Saturn V development because it was anticipated that this would be used as an upper stage for the Saturn V. It ultimately was terminated. I think as much for political reasons as for any other, the problems surrounding the clearances of flying a nuclear reactor from a land site at that time, with the potential overflight of other nations, lead into some other sticky diplomatic political issues. Which I think contributed to the ultimate decision to terminate that program. But Marshall was very much involved in the design aspects, the instrumentation, the control aspects of it. Of course the tankage, the plumbing systems and it was a fairly sizeable effort for probably three years. I have forgotten what the time scale was on that.

7. WARING: Can you remember how many people were involved in that?

8. ZOLLER: I would expect somewhere in the neighborhood of a hundred people. Not necessarily full-time, but a hundred equivalent people were probably involved in that program.

9. WARING: Do you think the decision that NASA made not to go into manned interplanetary exploration played a role in amending the project?

10. ZOLLER: Well, there were a lot of things that run into that. Certain some of the technology aspects. One of the interesting things is now with considerations of the Mars Missions, NERVA is in essence being dusted off again, because that is one of the propulsions options. I think that it is a viable option. There is of course, a inherent concern about using nuclear reactors. I think that by the time that we get around to doing a Mars mission, that a lot of that will have probably subsided. I think that we are on the verge of the re-birth of the nuclear power industry. I don't think that we can continue using fossil fuels indefinitely. I think that it is a matter of time before we are going to see

another generation of nuclear power systems. I contend that in the nuclear business, we are today very much where we were with the steam power plants in perhaps the early turn of the century. The problems were such that boilers were built with insufficient controls and safety margins that they were continually blowing up and killing people. Steam generating power plants were a real problem, which is what lead to formation of some of our societies, like ASME, to develop standards for steam boilers. I think that we are much as that same place today in the nuclear industry. It is not a matter that it cannot be worked, the technology cannot be developed, is that we have to recognize what the potential problems are, put the effort into it and solve those. So, I think that ultimately we will come to a point where reactors, in fact, can safely be flown. People can be convinced that it is safe to fly.

11. WARING: Doesn't the Soviet Union use small reactors to power their satellites?

12. ZOLLER: Yes.

13. WARING: Has NASA ever done that?

14. ZOLLER: NASA has not done that. NASA has used radio-isotope generators for power generation, but we have never used reactors. In fact, through my career, both at G.E. and here, I worked from time to time on proposed reactors for use in space. The SNAP reactors were space reactors. So, it is not something that is at all new. The technology is there. I think it does have its applications. Of course the Russians do use reactors. They had one come in over Canada if you recall. But NASA has been more cautious, let's say, in the use of reactors. Other people in the country maybe using reactors, but NASA doesn't.

15. WARING: Let's turn from NERVA to the Lageos Project. How did NASA get involved in that. That was a project that came through Program Development.

16. ZOLLER: Yes, it did. It started in Program Development. It actually started with a scientific requirement and desire, if you will, to very accurately measure the earth's circumference and topography. It came about at a time when the laser technology was beginning to mature. As a result of that it was determined that we could put into space, basically, a laser-reflector. By using laser range get very accurate measurements that would allow us to get the shape of the earth and to measure orbital decay and other things that I guess in part would confirm Einstein's theories of relativity. That particular project, which was a sphere about two feet in diameter, had the corner cube reflectors all over it. It was a project that interestingly enough, we took on in-house and built it in-house. It was successfully launched. We got very excellent data from it. The satellite is probably good for another two hundred years in the orbit that its up there.

17. WARING: Now when you say scientist have the demand and something of the design for this, was this particular scientific organizations, where geologist...?

18. ZOLLER: I don't know who the basic sponsors were. I know who the original sponsors of this were. But it was a maturing of technology when the laser industry began to blossom and the satellite capability was there, the ability to grind corner reflectors all came together. I think the scientific community at large recognized that this would be an excellent experiment or science project to undertake. It did turn out to be a very successful program. Bill Johnson was the project manager on that program.

19. WARING: Is he still in town?

20. ZOLLER: Yes, it is Charles William Johnson.

21. WARING: In effect Program Development then found that there were customers out there that needed this technology. Then program Development approached these people and said in effect "We can do this."

22. ZOLLER: That is right. Whether it came out of any scientific conference, any particular university, or group of science, looking for a mechanism to do this, I would have to go back and really look into that. I don't really remember how that came about. The basic work was done by Program Development. The program was ultimately transferred to the Special Projects and there it was manufactured and then watched.

23. WARING: A contractor designed the mirrors. Marshall assembled them and manufactured the sphere.

24. ZOLLER: That is right.

25. WARING: The design then, was a combination of these outside scientists and Marshall's work?

26. ZOLLER: Basically in-house, but of course, we did have a team of scientific advisors, industry advisors who reviewed the design and progress as we went along. So it was a cooperative effort, but the basic hands-on work was done here within the Center.

27. WARING: Was there a feeling at the time when Marshall got involved in the project that this was something new and new methods of organizing for working with scientists in this way?

28. ZOLLER: It was probably one of the earliest programs where we built a NASA scientific team, which we used quite prevalently on a lot of our other observatory and scientific payloads. It became a matter of practice for us to build this team. LAEGOS was likely one of the prototypes for that kind of arrangement.

29. WARING: At the time that this was being developed, people at Marshall set down and decided that they didn't have the expertise? So they would work carefully with the team?

30. ZOLLER: Well, I am inclined to think that the idea precipitated out of various scientific conferences and meetings. Through these discussions and meetings it was more a fact that NASA, and particularly Marshall, had the capability to produce the item, than we creating an idea and going out and looking for a market and filling in the areas where we didn't have the expertise. I think it more worked the other way, that there was a general interest in having a satellite with that particular capability.

31. WARING: There were scientists fishing around for somebody who could build it.

32. ZOLLER: That's right. We were at that time very interested in maintaining and exploiting our hands-on capability in order to utilize...we had an extremely capable machine shop and manufacturing capability at that time. We did not have capability for grinding mirrors on a large scale, although we did a little bit of grinding. I think it was more a marriage of convenience that we had a capability, we had an interest to fulfill a need that other people were trying to exploit. It was one of those things that we chose to use our own capability rather than going out and subcontracting for that.

33. WARING: Can you think of legacies from the Sixties and from the Saturn Program

that carried over into a project, like LAEGOS? Were there management techniques or manufacturing skills?

34. ZOLLER: Well, I think one of the very interesting things is, this is coming out of the Saturn Program. The Saturn Program was built in the "Arsenal Age," if you will. We had the capability to build the entire vehicle here at the Center. We did build the first stages, as you are well aware. During the Eisenhower administration, there was a conservative effort on the part of the government to disenfranchise itself from the government arsenals and turn more over to contracting. It was a hard pill to swallow, but we dismantled our large fabrications capabilities here at the Center. But for years tried and did successfully maintain some very capable speciality manufacturing facilities. I think that LAEGOS benefitted from the very specialized manufacturing capabilities that we developed during the Saturn Program. It also gave our existing cadre of manufacturing people the opportunity to really do a very precise high-tech job. If nothing else it utilized a resource we had available and to demonstrate to the world, in fact, we had that capability. I think that while we should perhaps, it never was our intent to be in competition with industry in the manufacturing of hardware, there was perhaps a fundamental error made in dissolving the arsenal capability of the government. There are very few places available where you have the hands-on expertise that I think the government needs in order to do its job. Part of the problem we have in terms of cost, and schedule slippage and technical problems today in all the major programs is in part attributable to the fact that over the past ten or fifteen years we have had less and less opportunity for hands-on work. Therefore our people are not ahead of the power crew, they are not anticipating the problems, they are not validating the production, manufacturing techniques. When they develop, we have to go in and spend a great deal of time and money to correct the problem. In the early days that tremendous arsenal concept that we had resulted in industry coming to NASA to find out how to do business, to find out how to get the information, the latest specs, the latest

materials and so on. Today our people can't even keep up with what is going on in the marketplace. I think that is one of the contributors to problems like, space telescope, for example. We don't have any in-house capability that tells us whether on a scale of anything of that magnitude, whether the grinding techniques are right or not. Whether the measurement techniques are right or not. If we had had fourteen thousand inspectors at that plant, it probably would not have made a difference.

35. WARING: You have to have people with that hands-on experience who have done it themselves to know what to look for.

36. ZOLLER: As long as the gear was set up there and giving readings and everybody said, "that's doing what it should be doing," unless it violates some specification, it isn't going to get picked up. I think, as I said, the LAEGOS was one of those programs that really benefitted as a spin-off of the arsenal capability. It was build during the Saturn Program.

37. WARING: Could Marshall do something like LAEGOS in-house now?

38. ZOLLER: No, not today. You could build the capability to do it in-house. But we have neither the technicians or the machinists and in many cases, the modern equipment to do it. We still have certain machine shop capabilities and so on. But our capability has been eroded to the point that I think it would be very difficult to take over any high-tech manufacturing end of it. I am afraid it goes really beyond things like manufacturing. It goes into really understanding what happens during testing. We have tried in the past five years to develop some hands-on capabilities here at the Center, particularly for the young people coming along who have never had the opportunity to kick the tires and make mistakes to find out what happens. The Technology Test Bed, we have a solid motor test bed, we have a bearing test capability. We have a number of test capabilities that were put

into place specifically to try to give the young people who are now the work force of NASA the opportunity to see hardware and see how it works. Unfortunately, even in many of those cases because of man-power limitations and what not, we have contracted out a lot of the functions that we envisioned originally that would be done by civil service people. Since I was a party to creating and implementing a number of those things, I know that from the very beginning we started out with the intent that they were going to be done all by civil service people. Now we find ourselves in a situation where the civil servant is just kind of on the outside looking in. This hands-on goes well beyond the manufacturing and testing. It is, I am afraid, even down into the design and the analysis, that we have lost a lot of our capability. There is no question in my mind that the younger generation that we have hired is every bit as smart and probably a lot smarter than we were, but they don't have the corporate memory and the experience that I had the opportunity to learn by mistakes. Therefore, we find NASA is moving more and more and more to a contract monitoring mode than it is a hands-on mode. I mean even down in the laboratories on thermal analysis or stress analysis.

Another concern in the same area is the tremendous capability we have of computational systems these days. It is a mixed blessing. We can run mass-tran models with a jillion modes and improve the accuracy to the point that it becomes nonsensical. You can determine that you exceed the safety margins or basically have negative safety margins on a thread of a screw. There ain't no way in the world to measure that and determine whether it is of any useful value to you or not.

The other thing is that the computer programs are getting so complicated that the vast majority of people that use those computer programs do not understand the physics and engineering that is taking place. They put numbers in and get numbers out. They don't know if they are right or wrong or indifferent, because they don't know what the program is doing.

39. WARING: The computer is operating its own world and the operator of the computer is removed.

40. ZOLLER: That is right and what you have to assume is that whoever did the program knew the engineering and physics or chemistry or whatever else was involved and made that program to do what nature does, and that is tough.

41. WARING: Do you think that you could fix a date at which point you could say Marshall's arsenal system and a lot of that hands-on capability was largely eroded? Was there a time when you just felt "ah, things are completely different from the way they were?"

42. ZOLLER: Yes, but I would have to go back and think about that. There were two things that I was tracking mentally as I worked through all those years.

One was the decay of the arsenal system. The other was the curve going in the other direction, the increase in the bureaucracy. You could just see the change over the years as those two factors lead from what was originally a very highly motivated, very capable, although let's say technically learning or immature group. In other words, we were pushing the edges of technology in every direction we went. People were very dedicated. People were very bright from an engineering and scientific standpoint, but we were pushing areas that we really didn't understand where we were going at times. I think that we had enough, at that time, enough dollars and enough capability meet and move in a multiple of directions, or move in directions where scientific principles were sound enough that we developed the data. The service organizations at that time were truly service organizations. They recognized that their responsibility and their role was to find a way to make the job happen. We have seen over the years a fundamental change as the agency matured, got older, got more conservative, got more bureaucratic. We lost a lot of the edge in terms of

motivation. The service organizations, instead of being facilitators, became impediments.

43. WARING: Since there were more limited resources, they began to act like managers who were trying to rein in people?

44. ZOLLER: That's right. Job security, protection, while not flaunted, was obviously a factor that you saw creeping in. As long as my job was to control this little pot of dollars, then it is my job to secure as long as I do that.

45. WARING: Because people were afraid of being RIFed.

46. ZOLLER: There was a certain amount of that. It was also a certain amount of human nature that this is my corral and I am going to protect my corral. But, there has been a very definite change from the lean, mean, highly motivated organization that we had back in the early sixties, to an organization from a pure educational and intellectual standpoint is probably more capable today, but it is hamstrung by lack of experience, lack of corporate memory, lack of hands-on capability, whether it is in manufacturing, testing or whatever, by the bureaucratic overload that we have in all the support systems which have become dominant. The raw capability that we have has really deteriorated in the sense of productivity. In fact, I think some of the problems that we have within NASA are due to the fact that we have too many people in certain areas. I think that you could do a much better, more efficient, more reliable job, if we got rid of some of the people that are creating part of this overburden.

47. WARING: In terms of administrative overhead, it is just too burdensome?

48. ZOLLER: Well, we have kind of gotten far afield from what you were asking!

49. WARING: No, this is interesting. This is all the stuff that we are involved in trying to learn about the Seventies.

50. ZOLLER: I was trying for years, I was actually watching what I called "creeping bureaucracy." You could just see it coming. By the Seventies, we had gotten to the point where the bureaucratic aspects were becoming very significant. As we got into the Eighties, I think that we reached bureaucratic saturation. I think that you reach a point where your decisions are being made on the basis of bureaucratic rationale and reason rather than technical or financial. I think that during the Eighties we reached bureaucratic saturation.

51. WARING: What caused this? Was it lack of funding, the decision to destroy the arsenal system? What do you think was the most important cause?

52. ZOLLER: Well, one was just the natural aging of the organization. Any organization because of what it is, as it ages, is going to grow more conservative. It is going to grow more bureaucratic in the sense that there is a lot of your bureaucratic aspects come from problems that or situations that arise. Then somebody comes up with a rule, or a law, or a policy or procedure, "that ain't never going to happen again, we are going to fix it." By the time you get done, you have piled on all these very regulatory or restrictive requirements. Almost all of those came about for a very good reason, because something came up. But with time, one loses track of why are we doing these things and they keep piling one on top of another.

53. WARING: And it is somebody's job to enforce all those rules.

54. ZOLLER: That is right. As that becomes into being, now we come into what we were talking about with this job protection type of thing, where it is my responsibility to enforce these policies or to generate policies, or whatever. When you talk about streamlining the system, then certain people become threatened. "I am afraid I might lose my job, because you are attacking what I do." Now the fact that they may be doing something far more creative in another area never really occurs to people. But I think that the natural aging...

55. WARING: It is an unintended consequence of....?

56. ZOLLER: That is part of it. Secondly, as we wound down, the Apollo Program and we tried to do ten dollars worth of work for a five dollar budget. We were spreading our resources and capabilities much thinner. That in itself, brings problems to the front. When you do that, that of course, helps to precipitate the policies and procedures. It also means that you have to be far more discrete in how you spread these resources. Not only the ability to distribute the resources, but the politics involved, become far more important in the decision making. When there are fewer dollars, fewer people to draw from to get the job done, you find that politics in the generic sense of the world becomes very important. You find that not only is it important to establish a very sound scientific and technical engineering requirement, you also have to worry about what is going to be the response of Congress, what is going to be the response of the administration. Those things become very influential. In the Saturn program, where we had basically one mission, where money was not the constraint, you had the opportunity to follow multiple course. You had the opportunity to provided an adequate test program, to provide backup engineering analysis and all those kinds of things. I remember the days when you discovered stress corrosion. The first time that hit was, we had a vehicle on the launchpad, I think it was 503, but we developed a stress corrosion crack in one of the domes of the H-1 engine. At that time, virtually nobody in the world really knew much about stress corrosion. We had some ideas

of what caused it. But when we attacked the problem, we sat down and developed a matrix of what are all of the physical and environmental influences that might cause or aggravate stresss corrosion. We developed programs in every one of those areas and basically threw enough money at it and resources that you solved the problem. Today, we don't have that luxury in the development of new programs. Every program that I can think of is hardware poor. We go in with the minimum test program. We don't have any kind of back-up hardware. If you drop a piece or break a piece, or blow up a piece or whatever it is, then there is a major [?] dollar and schedule-wise to go back and restructure the program. We are, I think, in a situation, because of the budgetary constraints that we are having to starve the development programs because we have so few opportunities to start new programs. Your driven to the point of trying to maximize the output, whether it happens to be the performance of the SSME, which we drove right to the limit, or whether you are trying to maximizes the performance of the HST, or whatever it is, recognizing that there are so few opportunities for new programs, you try to milk it for everything that you can get. At the same time, you would like to have a very sound, conservative development program, but what you have to do is to spread it just as thin as you can and still maintain some degree of creditability that you really think you might pull the thing off.

57. WARING: So, on one hand you have to promise people that this is going to be a super piece of technology that is going to do everything that people could ever wanted of it, but at the same time the reality is that you have to approach each part of that system with a very limited amount of resources, a limited amount of personnel.

58. ZOLLER: It is not so much as trying to sell everybody on what it can do. When the opportunity for a space telescope comes along, its not so much that we have got to push this thing to be able to do these things in order to sell it to Congress or anybody else. It is more the fact that you say, "here is a once in a lifetime opportunity. There are limited dollars

available, now how much can I squeeze out of those dollars available?" Now if you knew that you could in fact, build and fly four telescopes over a fifteen year period, then you might be inclined to say, "Well, on this first go around we will make the mirror sixty inches in diameter and we will do this that and the other thing. On the next step, we will do something different."

59. WARING: You will start with the Model T and then go on to the Cadillac.

60. ZOLLER: That is right. But, you are basically in an operating mode, where you may have a Chevy budget, but everybody is trying to make it look like a Cadillac.

61. WARING: Well, let me ask that question again about date. Is there a time when these forces that were changing Marshall and NASA came together? A time when there was the old NASA, the old Marshall, and then there is that new agency.

62. ZOLLER: There is, but I would have to go back and think about it a little bit. As I said, I remember consciously following this. Over about a five year period, in fact, I used to comment about the bureaucratization of NASA, and I would have to go back and look at some of my notes and what-not to pin down when that was. But it would have been in the mid-Seventies, when that process really began to...you could just see new policies coming out. A policy for this and a policy for that.

Another factor that enters into this bureaucratic influence, of course, is the leadership. Certain styles of leadership, certain personalities are more incline to drive you toward the bureaucratic end than others. Wernher von Braun was probably at the low end of the spectrum when it came to bureaucratic things. He was a manager, an engineer, a scientist, all of those things. But what von Braun was, was a visionary. He had the idea to conceptualize some grandiose schemes and then translate them into things that people

could understand and appreciate and that people could then go and implement. He used to drive us nuts. He would run around the country and see this that and the other things. He would start making claims that we could do this and we could do that. Then when the word got back to us, we would have to work like crazy in order to prove him right. But he had a feel, a sense of things that could be evolved and what they might turn out to be. Like I say, I think that his greatest value was that of a visionary. But he wasn't a "blue-sky" visionary. He had enough good solid engineering to know just how far to push it. He would come back and tell the folks here, "Well I think we ought to go and do such and such." Everybody would throw up their hands and say, "I don't think we can get there." But within a few months we would have reached that point. So he was more inclined to be a visionary and motivate people from that sense. From the pure rules, regulations, policies and so on, and of course in those days we were a much smaller organization, younger organization, we didn't need as many policies and we didn't have that many policies. Of course now you have an entirely different environment, where managers are trying to stave off manpower cuts and deal with budget fluctuations every year. They are dealing with how do you pack a wide spectrum of programs within organization and spread people around, it's just an entirely different management environment. It's the kind of environment that breeds more bureaucracy.

63. WARING: Would you attribute that to the decisions of center directors, or is it the environment that center directors were working in, in the Seventies and early Eighties. Is it a product of constraints imposed by Congress and the President, or do you have to know both?

64. ZOLLER: It think it is a part of both. Certainly there are variations from center to center on the degree of management overview, oversight, direction and control on restraint that you have. But, at the same time during the Seventies, as the Apollo Program was

coming down, NASA as a whole was fuddling for a mission, given the fact that there was to be a mission for NASA although there was still a lot of flux in it in terms of what it was going to be, there was a great deal of internal vacillation over what each organization's role was going to be. Everybody knows that we went through some very difficult internal fights and battles between centers, basically trying to define some turf. I think that everybody recognized that there was probably going to be enough work for everybody to do, although, there were very definite periods in the history of Marshall when the future of Marshall was on the line. I think that deep down inside, we generally all felt that we would weather the storm. But that caused the management to really dilute its attention on trying to define and implement programs, to marketing is what it really boils down to, to all the preservation things they had to bring to it. Of course, with the budget declining during that same period, there were some very, very tough years and very difficult decisions for management to make.

65. WARING: Do you think that Marshalls top management developed the feeling that the most important thing was not to make mistakes, to avoid mistakes, and yet impose control on people and that was more important than creating an environment in which people could be...

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66. ZOLLER: ...no that doesn't matter that ...our heritage at Marshall was built on technical excellence. Part of that technical excellence was built on conservatism. Going back to what I said, if you had a problem, if there were fourteen different ways that you might contribute to that problem, you would have to examine all of them, eliminate all of them and get down to solid facts. You had a back-up system to solve it. Everybody recognizes the "conservatism" as it was called at Marshall. I am not sure that is

conservatism. I think a lot of it was .... But, out of the von Braun environment and the excellence that was built there, that may have led to the preservation of that excellence, which in some cases, was more in appearance than reality. There was a belief that those, that all good things come to those that excel technically. Marshall was in fact somewhat naive in the realities of the world in the mid-Seventies. We were engineers. We planned as engineers. We built as engineers. We managed engineers. We failed to recognize that we were engineers in a political world. For many years we strove to maintain our influence, our capability and our future by our technical excellence. As long as we did the job right, [we assumed] that everything else would take care of itself. We found that we were living, however, not in an engineering world, but a political world.

67. WARING: Do you think that Houston was better at playing that political game than Marshall?

68. ZOLLER: I think that they were better gamesmen, in fact.

69. WARING: Do you think that they had inherent advantages because they controlled missions operations?

70. ZOLLER: No, not particularly. We have debated engineering development versus operations for years and years and years and years! Probably still will! I think that Houston was perhaps more politically astute than we were. That probably in itself, was a large contribution. But the people that grew up as the management nucleus at the Marshall Space Flight Center were very dedicated to maintaining a very strong engineering capability. In the face of this rather strange political environment that we found ourselves in, there was also a strong inclination to maintain the image of excellence. Like I say, sometimes it was more in appearance than it was in reality. Any chink in the armor was

potentially disastrous, the whole stack of cards would collapse on us. So, we found ourselves I think that even in those areas, while we were trying to fight political battles, we were draining our engineering and technical capabilities in areas where they should have been applied.

71. WARING: Could you give me an example of the sort of thing where personnel was being channeled in one direction and maybe it should have been going others?

72. ZOLLER: Well, let me cite one example because I think today, if you want to trace history, I think that today, right now one of the major problems confronting, first of all Marshall Space Flight Center and then secondly the agency and then thirdly the industry at large, is a lack of systems engineering. I guess we started out, the von Braun team built in a very strong systems engineering capability. System engineering is not something that you can go to school and learn. It is something that you have to have a lot of seasoned, disciplinarians from a variety of fields who get together and look at things from a total holistic viewpoint. I think that the whole strength of the Marshall Center was largely due to our systems engineering capabilities in the sixties.

73. WARING: This was a product of the interdisciplinary teams making sure that the whole package worked together.

74. ZOLLER: Everything was looked at as a system. When you stood back and said this thing has changed, what effect does it have on the all these other things. As one of the products of the political in-fighting between Marshall and Houston was that ostensibly, the systems engineering role was, take Shuttle for an example, went to Houston. For a good many years, we were doing a lot of the systems engineering for the shuttle. In fact, we have certain tasks that we were responsible for. As time went on, attitudes were that if that is

Houston's job, then we ought to be putting our resources elsewhere. So we pulled off our systems engineering on the shuttle and put them to doing systems engineering on other things. Then with time, system engineering started to decay altogether. We used to have systems engineering as a prevalent circumstance through the whole center. Then it became concentrated only in a few specific organizations and even they were timed, either through attrition or break-up and re-organization and diminished to the point where we ultimately disavowed any systems engineering responsibility or support for the shuttle. Today we have virtually no systems engineering capability at this center. Now, there are some people that take issue with me on that. What little systems engineering we have today, probably resides at Program Development.

75. WARING: Let me see if I got that story right. Now, in the Sixties there are these dozens of teams, really, that did systems engineering in a decentralized way, right?

76. ZOLLER: Well, the whole center really was...there was a focus on systems engineering. But the materials people would get with electronics people, structure people and we would all work to solve the problems for each from the different perspectives.

77. WARING: Above each of those teams were better teams and so on up the line. The Center aged through the Seventies and Eighties into the Shuttle Project, systems engineering became the role of experts, is that what I heard you saying?

78. ZOLLER: No, it became focused in certain specific areas. Either certain technical areas, or certain individuals, or groups of people that had a feel for systems engineering and it lingered in those functions. But with time we have not done anything to try and preserve or build a systems engineering capability at the Center. We find ourselves today with a derth of it. This manifests itself when we see [it] in problems in our current

programs, that as we enter into programs, requirements are not totally defined. We find that we make a lot of changes later to correct deficiencies in requirements or add requirements. We get into technical problems and then spend a lot of time and money trying to solve them. A lot, if not most of this, in my opinion, is traceable to a lack of good, sound systems engineering approach to start with in defining the requirements and then a good sound systems engineering approach. Today it has become even more tragic, that not only do we not have the capability that we used to be able to provide that systems engineering oversight for our contracts, but I find in industry that most contractors don't know how to spell SE&I, Systems Engineering and Integration. They talk about it, but when you really get down to it, unfortunately our industry is not able to understand systems engineering either. I am afraid that is going to be one of the major problems we have, particularly when you take on the magnitude of the space station or a Mars Mission, systems engineering has got to be a very vital ingredient. I think that is probably one of the areas that we are suffering from the most. If you take the situation that we find ourselves in today from where we were thirty years ago.

79. WARING: So the result of that is development work has gone piecemeal. There are individual groups working on parts. Then there are a few individuals that after the fact, have to integrate those parts together as best they can?

80. ZOLLER: Well, that's right. Everybody is off working on their own pieces. It's a matter of specialization.

81. WARING: So that is another part of the bureaucracy era.

82. ZOLLER: It used to be that the family doctor was a systems engineer. He did the whole body, but now you have to have fifteen specialists. Unfortunately our technology is

driving us to that situation in engineering. When a problem comes up, if it happens to be, let's say, a structural problem. The structural engineer comes up with a design fix. The fact that influences with the fluid flow really isn't taken into account. The fact that the fluid flow affects the performance of the engine isn't taken into account, so that when a problem comes up, they band-aid the problem and it may be from the structural man's viewpoint, the ideal solution. But from a systems standpoint, it might not be the right way to do it at all. I think that is some of the things that we are struggling with today.

83. WARING: Is that just then, not just a failure of systems engineering, but a failure of aerospace matrix organization to work effectively. The whole matrix assumes that these teams are formed and work. What you are saying is that you might have these teams, but they are not really integrated?

84. ZOLLER: Well, ultimately, the management factors into that. But again, we are getting into such complex programs that somehow or other, the general perception is that project management needs to be omnipotent. The programs are of such magnitude and so complex that there just isn't anybody that who could do systems engineering. I have heard them say here at the center that, well, we have got systems engineering. That is the job of the project manager and the chief engineer. Well, that is not systems engineering. You can't have one or two people trying to keep all of these things in place, look at all the options. That is not what we mean by systems engineering. I think that with the increased complexity of the programs, that unless there is a substantial reemphasize and re-dedication to systems engineering, that we are not going to get the maximum productivity, the maximum benefit out of these programs. We will probably continue to limp along and do things that aren't even necessary to be done. When you get into problems you try to bail yourselves out. But I don't think that we are going to keep ourselves out of problems that way.

85. WARING: Is systems engineering also made more difficult by the fact that the Center is now involved in very many projects, whereas with in Saturn years it was basically a propulsion center and that was it.

86. ZOLLER: Yes, and it is also from a fact that, as I say, we are losing so much of our corporate memory and have over the last five years and over the next five years we are going to lose so much of it, that today we have only got one or two people that I would really consider structural engineers with systems engineering insight. If you go back to the Center composition as it was in the sixties and seventies, everybody had this systems engineering consciousness. There were experts all over the place. As time went on, through attrition, you got where I had one person that I would trust, if you will, in structures, or one person in propulsion, or turbo machines. If I really wanted to have a question answered, I would go to that person as opposed to a team or group of people. As I say, I am afraid that while we have people that are very, very intelligent, far better trained than the group that we had thirty years ago, they just have not had the experience base. They haven't learned the kinds of things that are necessary for systems engineering. When you have a problem, it doesn't really say to them, well this really isn't a structure problem, you need to go work this with so and so over here.

87. WARING: They try to work it out on their own?

88. ZOLLER: They probably don't even see the real problem.

89. WARING: That's very interesting.

90. ZOLLER: We are currently looking at a special studies, some of the things that should

be done in order to correct some of the deficiencies that we have. Like I say, when you talk to the people that are managing various programs, it becomes after the first interview, very repetitious. You get down to the point where you find lack of good systems engineering and there is a threat to every program we have of the "buy-in syndrome." That is a threat to every program we have.

91. WARING: What do you mean by that?

92. ZOLLER: I mean two things. Number one is going back to the fact that the opportunities for new starts are so few and far in between , that when you get an opportunity to start a new program and then the budget picture begins to look a little bleak. You either are encouraged, or suddenly you find that instead of a hundred million dollars you can really pull this off for eighty million. Then it becomes maybe seventy-five million, then seventy-three, then seventy. There is a tendency for fear of losing the opportunity, totally to reshape it to the point that it severely increases the risk. If you started out with a hundred million dollar program, well then, you may have agreed to do it for seventy, and then it is going to cost you one hundred million and another fifty on top of it. But it is a way that the risk of the program gets dramatically increased. We do it from NASA's standpoint. The contractors because of the highly competitive environment, obviously comes in and scales the program back to almost unrealistic levels. They "buy-in" if you will, for a much lower cost then what it is really going to take to do the job. Those are trends that I think have got to be reversed. We have been trying to get the message to industry for sometime, that we are not interested in low bidder, that we want a realistic cost estimate. We are going to throw out all the contractors' proposals one of these days because it is unrealistically low. I guess that is going to be the only thing they are going to listen to when we do that. But, we are not free of culpably in that area. Because in our dealings with Congress and OMD if they cut the program by X millions of dollars, we say,

well, we still think that we can do it.

The other thing that is associated with the resource is that even when we start a program, we drastically underfund the early years of the program. We start out with here's what the requirements are and then every year it is a matter of "well, this is a tough budget year. Let's cut back this year and then you can make up next year. We will get the money for you next year." Well, next year never comes. It is the same process year in and year out. So, the front ends of the programs, I would say the first three to five years, the programs are drastically under-funded, which means that you are working on one profile. Then you are constantly reprogramming it. Now, if you knew what the funding level was going to be, even if it was lower, you could lay out a program and go do it in a very stable, logical way and be far more productive. But it is always an up and down. You are working on this curve and you cut back. You start up another slope and cut back. That is a disastrous way to manage programs. Systems engineering, I mentioned the fact that the programs are not adequately researched, defined and analyzed in terms of their sensitivities. Where you have high-risk processes, for example, or high-rise involvement activities. Those ought to be funded with multiple courses of action so that you can make a choice and have a back-up in case it doesn't work out. Again, because of the funding restraints, we just seldom do that. We find that there is generally too little attention given to the operational aspects during the early development phase. We start out trying to minimized the developmental risks and as a result pay through the nose in the operating end of it.

93. WARING: NASA assumes once something is in development and it isn't working, Congress will pay to make it work?

94. ZOLLER: I think that it is endemic in our society, you can take almost any appliance that you have, or your car; it is getting to the point where you just can't repair it. You can't

work on it. You can't keep the thing functional. It is a major job to go in and do anything. We have been guilty of the same thing. The Shuttle was designed, basically, to minimize the development risks. You get the think going, but from the operational standpoint, it is a nightmare. If you were designing it for twenty-five or fifty years of operation, it should have be designed far, far, differently than what we have today. That is true of almost everything that we do. Again it comes back partially to this "buy-in" situation where the difficulty in giving adequate definition and development moneys, you say, well, I am going to build it this way because it is the state of the art and I know I can do it this way. The fact that the poor guys who have to operate it has to spend three times that in order to keep the thing running is not part of the equation.

So, in one way you can say that given all these problems, constraints in the way of doing business, the politics and so on, it is probably miraculous that we have achieved so much success that we have gotten out of it. Certainly it is a rationalization for some of the problems that we do have. But that is sort of a cop-out. Turn around the other way and say having learned from that, then we have got to somehow form a partnership with the administration and Congresss to understand that when you enter into a program, that there are just certain fundamental processes that you have to go through in order to have a successful program. You can't be dickering around with these things every six months. You know, starting them up, slowing them down, stretching them out and doing all this nonsense, and have any hope of having a truly successful program.

95. WARING: Do you think the European Space Agency's budgetary process is a more rational one, where they have a smaller budget, but are able to predict in the future what their funding will be?

96. ZOLLER: From that aspect I think NASA would benefit from multi-year budgeting, which is what you are really getting around to. If you knew what you budget was going to

be, you could get around it.

Now, I answered that question that way, because ESA budgetary project process is a "black art." It is absolutely amazing that they ever get anything done. Country X contributes, lets say, 7% of the budget. According to the rules under which ESA works, 7% of the work has to be put back into that country. Well, the expertise of that country might be in a system that calls for 16% of the cost of the program but they only put in 7% of the money. How they ever accomplish anything is amazing to me.

97. WARING: So that is not the ideal process?

98. ZOLLER: No, but the end product of having a known and projected budget that you can count on, that aspect would be heaven. If think if we really knew what our budget was going to be...well, we are going on a 15 billion budget this year. If you really knew over the years what your budget really was going to be, you could probably get by for something less than that, because you could build the program in a way that was going to utilize the projects in the best way possible.

99. WARING: That would at least solve the monetary problems, at least the problems on deciding what sort of technology is best, development versus operation. It would eliminate the problem of integrating all the little bits and pieces.

100. ZOLLER: Every new program that comes along is the sacrificial lamb. When you get into the budgetary problems, Congress cuts back on the budget or whatever, the tendency has always been to maintain the funding of the mainline programs and try to solve the problems by cutting back on the new programs, "well, we can delay those programs a few months and take 60 million dollars and put it into the shuttle flight." There has been no protective shield, whatsoever, for new programs and that is the first place you go to look for

when you are trying to look for moneys to bail out the rest of the program. That is disastrous.

101. WARING: That results in low morale and turnover in those smaller projects?

102. ZOLLER: Well, it does that and... We go out with an RFP and select the contractor that theoretically or the contractor that provides us with the very best optimum design program. Before you ever sign that contract, you have bastardized it to the point that makes it just ridiculous. You stretched out the time, you have changed the funding profiles, you have done all kinds of things that completely invalidate the highly theoretical and highly motivated kinds of objectives that you are striving for. But the system says that the money you planned on isn't going to show up, so you have to restructure the program. You are constantly... Now when that new program gets its feet on the ground. People say, "okay, now we have to fund that," then that program is funded at the expense of the next program. There is no protective shield for the front-end of these new development programs. That is just a disastrous.

103. WARING: Well, that is a very interesting explanation of some of the problems that NASA is working under. Could we go back and discuss some of these other projects?

104. ZOLLER: Yes, now that we have solved the global problem!

105. WARING: Projects that you were working on in the seventies and maybe you can relate them to some of these general trends you described in Marshall.

106. ZOLLER: Let's take politics for example. We mentioned that we were working on solar heating and cooling. Obviously during that period of time, the crisis as far as oil

availability led to a great concern for conservation and so on. The Department of Energy was given again, by the Congress as a new program, large moneys to go out and develop and alternative to fossil fuels. That is just another case of what we have been talking about. Here was a very sound, what seemed to be a very beneficial goal for the country. They poured a lot of money into it. DOE wasn't really equipped to handle that job. As a result of that..

107. WARING: You mean they had no research scientists or....

108. ZOLLER: And they had a very small organization at that time. DOE was a very small regulatory organization. All of a sudden this crisis came up and Congress said, "well, here is a blank check. Go out and solve the problem." Well, they just didn't have the resources in terms of people or expertise to really deal with the problem. They made some very significant gains, but we entered into a partnership with them in terms of solar heating and cooling, for residential and commercial entities. Again, a humongus program was laid out with all kinds of demonstrations and all variety of things to incentivize the public to chose solar energy and to demonstrate the benefits and so on. That was pushed for a couple of years and then you started seeing budget cuts and scaling back and redirections. Deemphasis on one program and emphasize on another. We were very instrumental in the development of a number of demonstrations. Again, we approached that from a systems engineering standpoint. We said, "now what are all the problems that you have to deal with. How might you translate solar energy into use on that. What are the best approaches?" From that we chose a number of them. We did install a number of demonstration projects around the country. As the oil crisis began to ease and we went back into normal mode of operation, the interest waned. The relative cost advantages between solar Energy and fossil fuels diminished. So, over a period of probably four years, five years, it became the great hope and then diminished down to the point where it was

totally dropped. But there were some very excellent work that came out of that. I think that technologies were developed. I think, in retrospect, the country erred in not going ahead and investing in solar power as a hedge against the kinds of problems that we have today.

The technology is there. There were a lot of good systems that came out of it. I think that Marshall did a very good job, but it was not a job where we really had our expertise. When we took on that role, it was during one of these periods when we were fighting for our existence. We had resources that we were pedaling. It really wasn't as much of an engineering, scientific role, as it was a management role that we were doing for DOE. We were managing the contract development and installation of various demonstrations around the country.

109. WARING: So Marshall people weren't in the laboratories.

110. ZOLLER: We had a few. We did do some work internally. We did have some test facilities here that we were using.

111. WARING: What sort of things did Marshall do? Was it solar cells, passive solar systems?

112. ZOLLER: Well, we were developing a number of liquid systems, where we had primary and secondary heat-transfer systems. We were developing, in-house, fluids that were good heat transfer materials, but were low in corrosion. We developed various kinds of materials and joints to use the lenses, or screens. We were looking for all kinds of different solar applications, the direct heat transfer through absorption. We had concentrators that we were using. We developed ranking cycle, heating and cooling systems. Across the board, it was a matter of good interesting, fun, engineering

applications, but it really wasn't in our line of business, per se, but we were using a lot of our capabilities that we had developed during the Saturn and applying it to this industrial application. I think that the result was a real spin-off of technology. But because the nation chose not to really maintain this enthusiasm about conservation of fossil fuels, it just died out. That came and went.

I do believe that the space program and Marshall in particular, made a real contribution in that area. I think, again, one day, solar Energy will become more important to us again. I think that there is a good technology base to go back and draw on to go back into that area.

113. WARING: During the solar Energy research projects, wasn't Marshall developing a different kind of relationship with contractors, than say during the Saturn years? Could you describe that?

114. ZOLLER: Yes. We were really getting involved in a commercial market. Historically, again going back and drawing upon our arsenal heritage, we had grown from an organization that so strong and capable from a hands-on standpoint, that from the very inception of NASA and in particular Marshall, we were in the contractor's knickers day and night. He didn't do anything that we didn't have somebody looking over his shoulder that really knew what they were talking about. Contractors, aerospace contractors, didn't appreciate that all the time. But as long as we had that hands-on capability and that experience, then we were in a position to make a contribution and we saved NASA millions of dollars that way.

Now we found ourselves dealing with an entirely different element of the industry phase. We had to give these contractors, basically their commercial environment of free-reign. So NASA found itself struggling to make a contribution technically. Yet, forcing itself into another culture. That was somewhat traumatic for us.

115. WARING: What would happen then? The contractor would be working on solar energy and he would run into a technical problem. Would he then present that to Marshall to be fixed?

116. ZOLLER: Yes, that is right. If they said, "we have a solution," or if they came to us and said, "Can you help us with this," of course we were delighted to do that. Sometimes we offered suggestions. But basically we had to depend on their capability to do the job.

117. WARING: Marshall was acting as a commercial research lab.

118. ZOLLER: Yes and as the contract manager. We functioned for DOE. We tried to do enough in what we thought were the high-risk areas in the laboratories, to keep our people at least intelligent of what to expect in terms of problems, and how to go about solving them. But it wasn't like our later and earlier involvement in terms of our in-depth penetration of what the contractor was doing.

Now over the years, interestingly enough, we have maintained our culture of staying in the "contractor's knickers." But, as we have said, with the demise of the arsenal concept, the benefit of that, from time to time has probably deteriorated into we still were in there looking, but we weren't able to make as much contribution because we didn't have as much in-house capability.

119. WARING: Might not have known what to look for and even if you saw something you might not have recognized it as a problem?

120. ZOLLER: As I say, we probably went from preaching to meddling! I frankly think that it is important to maintain the government's detailed involvement in what is going on.

I think that if you do that without having the expertise to back it up, you probably are more part of the problem than you are part of the solution. At times, I think that we have found ourselves in that position.

But this was an entirely different environment and out of that lead to some later involvements we had in terms of commercialization. Where were trying to promote, not contractual relationships, but entrepreneurial relationships between NASA and industry. This came to bloom in the material processing in space. We drew upon very heavily, our engagement in the solar energy activities in terms of trying to work with industry. In terms of what are their long-term needs, how can space be beneficial to that. Trying to get them to use their moneys and give them latitude, but still within the constraints that were important for the safety of the vehicles to operate. Richard Brown, I think, made some real significant contributions in the area of commercialization. He worked for me in material processing. That was a great benefit. We are still kind of twiddling around in commercialization. But, it really doesn't have the fervor that it had probably in the late Seventies. Again, that was a change in our relationship and think that out of that commercialization, out of the work that we did with solar heating, that certainly influenced how we dealt with the scientific community. When we started getting into the large observatory, like HEAO and on into the large space telescope, AXAF and so on; where we formed scientific teams and consortia, and working groups, oversight groups, to try and give industry and scientific community a much larger role in determining what the requirements were and also make them feel responsible for the decisions that must come in terms of how you ultimately are going to engineer it. From a scientific standpoint, they almost always wanted more than you could give them. But they weren't always willing to accept the compromises and restraints. But I think that we developed a working relationship, first of all with the industry in the solar business. Then through commercialization. Then through scientific community to make them more part of the engineering management team.

121. WARING: Was that necessary because Marshall was breaking into new areas where they lacked expertise, so Marshall was almost forced to rely on industrial and scientific expertise?

122. ZOLLER: There was a certain element of that. I would think that it was more a matter of practical survival. We recognized that we were getting into areas that were not our domain by divine ordinance and we had to basically build a lobby or a following or constituency. I think that it was a matter of prudency that we consolidate our role here. While we were recognized for engineering expertise and while we felt we had some very excellent scientific capability, we also realized that we did not have a scientific constituency nor were we recognized as having a strong scientific capability. Whether we had it or not was immaterial. So we set about to create a team that would have the scientific visibility to go along with the engineering visibility and the management visibility. So it wasn't entirely by accident, it wasn't entirely by...

123. WARING: Well, after fifteen years or so of existence, the Center developed some political savvy.

124. ZOLLER: That is right. It was political savvy.

125. WARING: Tell me so more about the materials processing in space. I will just start out with something I have been told by somebody else. Another person I interviewed this summer told me that Marshall had an opportunity to develop a leading position, or THE leading position in materials processing in space and flittered away this opportunity in part due to management errors and in part because the Agency did not support Marshall in developing expertise in that area. What do you think of that?

126. ZOLLER: I was out of town for part of that! First of all Marshall did have the opportunity to be the leading role in this. There was a great deal of interest. Dr. Lucas was personally, very interested in this. I think that material processing in space suffered from two fundamental malignities. Both which we have touched on at one time or another here. One was that it was it did not enjoy a lot of support at Headquarters. There was an organization formed. They brought in a super individual, John Corruthers, who had the scientific credentials to really make something of that. But again, that program found itself politically naive, in that it was trying to build a strong technical and scientific program when the politics were against it. Everybody was constantly saying, "Well, what is the compelling reason for this?" What they wanted was the "six-pack" solution...

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127. ZOLLER: ...program on the basis that it's going to produce ultra-pure crystals so that we could have all kinds of wonderful things in-house and so on. I think the expectations were higher than the potential for reality. So there were two forces that were working that were mutually exclusive, but they operated in the same environment. One was that there was a lack of priority put on material processing in space relative to the other programs going on. At the same time, the agency was trying to milk material processing in space as a star in its crown. Again, with all of the wonderful things that agencies can do, promoting to Congress their expectations of things that were going to come, but given time and money would have come. So I don't think that this difficulty that we had on the one hand, giving a lot of lip service and visibility to material processing in space, but not really giving them a whole lot of priority. That is the dichotomy that the program struggled with . The other one was that it was a ten-pound program put in a five-pound bag. We never had the resources to the job. Material processing in space operated on about a two to two-and-a-half million dollar a year budget.

128. WARING: That's here at this Center.

129. ZOLLER: That is here at the Center. The Center was probably 60 - 70% of the total program. Programs like the shuttle don't even round off that program. As a consequence the ultimate downfall of a major thrust in that area, was that there simply was not enough money to do the job that needed to be done. It would have only taken another couple of million dollars to have solved those kind of problems. So that was last back on the degree of priority that was given. I think there was some very good work done. John Corruthers, I think, was very instrumental in getting some very excellent fundamental chemistry and physics done which is going to benefit that program for years to come. The prospects were there to achieve a great deal in terms of missions on the shuttle. But then the shuttle manifest began stretching out and getting flights were very, very difficult. We started out with a concept of mid-deck experiments that were to be basically experiments of opportunity for the space. We would put it in. If it worked fine. If it didn't, well then no big sweat. We started the program in that context and started building hardware in that context. Then ...

130. WARING: This was then in the late Seventies?

131. ZOLLER: Yes. Late seventies, early eighties. Then when it came time to integrate it into the shuttle, for example, then we started to find out that here are all these additional requirements that people were putting on it. They were getting a lot of visibility in safety requirement. It was driving the program in an entirely different direction. We were building it like a one time observatory or spacecraft, it had to work the first time. So the whole concept of the flight that it was, when we started, like I said was, the work that was agreed. Of course, you wanted it to work, but if it failed, it wasn't a catastrophe, you could fly it again on the next flight. But, it became so difficult to get manifested, and so difficult

to deal with the bureaucracy that had built up on flying on the shuttle, that ...

132. WARING: So this didn't have to do so much with the fact that shuttle flights were, perhaps more expensive and less frequent, it had to deal with the regulations that were imposed on the shuttle flights themselves.

133. ZOLLER: It had to do with both. When the flights began to become fewer and fewer over density increase and with the decrease of density of flights, the opportunities for flying and the conditions for flying. The opportunities decreased and the conditions for flying became far more severe. So amid that I still believe is something that we ought to really be promoting as the very flexible easy laboratory for people to get in and do things inexpensively and so on. It was costing us as much if not more per pound of experiment to put an experiment in a flight-deck, than it was to put two big things in the cargo bay. That was a difficult thing. One of the real problems that we got into was with the one of two major instruments that we had planned for materials processing in space that were being build by TRW. TRW did a good job on those. Again, it was a development program that was built on a very scrimpy budget. We got into some problems. Finally it was decided to bring the program in-house to do it. Unfortunately, our in-house capability was not there to support, it was not properly organized, made available with NASA means. So it went through a very traumatic period of time. But, fundamentally the issue was that if you were going to try to do a scientific program of the magnitude and of the competency that people, like John Corruthers and Bill Lucas and others wanted to happen, you just needed more money to do it.

134. WARING: In Marshall's standing in the Science and Industrial communities doing of materials processing in space, was Marshall sort of at the peak of its achievements in the eighties and then deteriorated from there. Or was Marshall playing just as leading a role as

it did in earlier periods?

135. ZOLLER: Today?

136. WARING: Today.

137. ZOLLER: Well, we are still doing some things in that area, but to my knowledge, it is not a concerted program, it is quite of an appendage, as opposed to a program, project or major thrust. Material processing in space is an expertise that we have. Back in those days, we had a staff of very excellent people, both in Materials lab and the Space Science lab, who developed some scientific standing creditability on their own because of their work. We don't have that capability today. Those people left. When John Corruthers left the program, he finally got so frustrated with the politics in Washington, he decided to leave. John had scientific creditability and standing within the scientific community. When he left the program right there began to deteriorate because he was a very ambitious and aggressive proponent of the program and budget deliberations and planning, even though he hated the politics, he was very vocal source there. So he kept a lot of things going. He was very bright scientifically. He knew how to apply the techniques and developments of one technology or discipline into another discipline. He was very good at that. When he left, out of frustration, the scientific creditability of the program began to suffer. Also the financial backing which was weak at that time anyway, suffered. So the competition for that program and other things like Space Sciences, all their big money was going into communication satellites and things of that nature. Material Processing was kind of a wart on the system. I don't really think that for the kind of program that was trying to be run, that we ever achieved the critical mass of funding. Now, given the funding, if somebody had turned it around and said, "You are never going to get more than this amount of money per year, now go out and build a program within it," that could have been done. There

again, it is trying to milk a program for all the benefits that you could get out of it and hope that you get enough money to get you by.

138. WARING: Were there problems of other centers or headquarters wanting to get in on the materials processing in space business?

139. ZOLLER: Oh, there was some but not seriously. I think that there was enough work to go around. JPL, who was involved in the program, did some excellent work. We had some very good work going on there. JPL was really the only other major competitor, if you will, with Marshall. I really don't see it as a competitor. Langley was doing a little bit of work. There was a little bit of work going on at Lewis. Again, John Corruthers went to various centers, found what there areas of expertise were and tried to bring them into the program. I think that Marshall would have liked to have the whole ball of wax and said, "We would ride the front of the horse." We probably did pretty much ride the front of the horse, although it was banished out of headquarters. While there were certain areas of competitiveness, I frankly think that it was healthy. One particular area was both we and JPL were working on acoustic levitators. I think that both were doing very good work. We took two different approaches. We ultimately ended up building devices that were a configuration of both designs. But, while some people would probably would have liked to have Marshall as the one and only contributor in this area, I think the competition there in that area was probably healthy. I think all the organizations should be very proud. I don't think that had anything at all to do with the demise...it really wasn't a demise, I shouldn't use that term. It should be the deterioration, the weakening of that program.

140. WARING: Was it Marshall's experience once again back from the arsenal system in building things that gave it the leg up in materials processing in space, or was there efforts to recruit people?

141. ZOLLER: No, I think the thing that really gave it was, that going back to the Saturn days, Marshall had the preeminent materials science and engineering organization in the country, if not in the free world. I think that I am probably safe in saying that. And for that I give credit to Bill Lucas. He built a materials organization that was second to none. In those days industry came to Marshall. Even in those early Saturn days, we were spending an appropriate amount of our energy and resources on fundamental research. We were working back in the early sixties on the space station, what kind of materials would you need for the space station, micrometeror shields and so on? What could you do with a space station? So we had an organization here at the Center that I think, had a very good appreciation for fundamental research, applied research and engineering. We also had a Space Science organization that was doing very good work in terms of things like fluid dynamics. So, the Center had, when Bill Lucas became Director, an inherent recognized capability in Materials Research and had been doing work in the material processing in space. That was something that Bill Lucas envisioned for a long time that would be a real payoff.

Plus, we had the engineering capability to build small furnaces and things of that nature. We built experiments on a shoe-string. Sometimes we got into problems with those, but it was matter of ingenuity, people going out and scrounging and putting stuff together. But the real impetus came from Bill Lucas' strong interest in the materials science and the material science in space tuned with the engineering capability that we have. That is really what lead us into the microgravity work and the materials processing in space activity. Bill Lucas was very instrumental personally in bring John Corruthers into that headquarters position. He was very instrumental in promoting materials science in headquarters. But, by the same token that we didn't always put proper resources on it here in the Center, in order to get the job done. I think that almost every project that I can think of during that particular era of the administration that we did not put the resources on the

job commensurate with the expectations and we fell short in several of them.

142. WARING: Was there much contractor involvement in Materials processing, other than constructing experiments for Spacelab?

143. ZOLLER: No, not a lot. Of course the big contract that we had was with TRW for Spacelab experiments. Those I think were very good experiments and perhaps still will produce very meaningful results. We had some small contracts with companies to help us build some small parts. Most of the contracts we had were more with principal investigators, funding their research and their flight experiments. Basically, I think, that we were providing the experimental apparatus. The scientific community were developing the experiments to use those apparatus.

There wasn't a lot of contracting, but I would say if that if you, other than the TRW contract, the bulk of the contracting that we had was with science and industry in terms of experiment development.

144. WARING: That's make sense. Why don't I close by asking you some questions about where I can find some written information about some of this stuff. Would there be written documentation on Materials Processing in the Materials Lab, do you think?

145. ZOLLER: A better place to start would be in the Payload Projects organization. If you will go and talk to somebody like Roger Chassi, or John Price, I think that Roger has still got his finger in the microgravity work. I think there still is a small team of people over there that are still working on microgravity and they should have access to the test results and documentation that came out during this. I think that we got some excellent results out of things like SPAR flights.

146. WARING: Would there be a report on them?

147. ZOLLER: There would be a report on everyone of them. There was one, a major report of the Material Processing experiments that were done on Skylab that came out as part of the official Skylab documentation series. There were reports on every SPAR flight. There were several, there were a document every year that catalogued the all the work that going on in Material Processing. There is a lot of documentation of the programs and scientific results. Another good person to talk to would be, Bob Naumann in the Space Science Lab.

148. WARING: He is at UAH now.

149. ZOLLER: Bob has an extensive background, he was a Chief Scientist.

150. WARING: How about for LAGEOS?

151. ZOLLER: Bill Johnson would be the person. I don't think I have any documentation on that, but there are reports that should be in the repository.

Solar heating and cooling, again, there is a whole bunch of reports that should be in the repository. Probably one of the best persons in that area, who doesn't happen to work for NASA any more, is Don Bowdon, who has his own company here. He left NASA and went into business manufacturing solar heating devices. Then the market fell out and he has gotten into other things now. But Don Bowdon was involved in that.

John Price, who is currently working on TOW satellite, but he is involved in Material Processing in Space.

152. WARING: Is there anything else that you think a historian should know about

Marshall?

153. ZOLLER: Um. NASA is not the organization today that it was thirty years ago, but that is not all bad. I think that we have become far more diversified. We have developed a tremendous technological base across all of the centers. We are given blame currently for losing our "can do" attitude and capability. I don't think that is true at all. We obviously have made mistakes. We deserve to be criticized for mistakes that we have made. We also have tried to be miracle workers in terms of doing things that, while technologically may be accomplished, have been made very difficult by the political and managerial environment that we have worked in. The agency has become far more bureaucratic as we have talked extensively today. I think that is a detriment. As far as the technical capability of the resources, the people that we have got, there is no question in my mind that we are a far more potentially technically competent organization today than we were thirty years ago. What we have got to do is try to transfer somehow, the corporate memory of those of us who are reaching the "twilights" of our careers to those who are coming in. That is not at all going to be easy.